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Estimating Boltzmann vibrational temperature of N2 (B^3Pi_g) using ISUAL 630nm, N2 1P (623-754 nm) and 762 nm-filtered imager data

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Multi-band observation of transient luminous events (TLEs) is one of the useful methodologies to be employed in sprite campaigns. Here, we show a method to estimate the Boltzmann vibrational temperature of N_2 ($B^3\Pi_g$) by analyzing the 630nm-filtered, N_2 1P-filtered and 762 nm-filtered images of TLEs. Our advanced method is validated in compassion with derived relative vibrational distributions by sprite spectrum (Kanmae et al., 2007). The imager recorded N_2 1P-filtered emission ($I_{1P,}$ 623 – 754 nm) of TLEs indicates the intensity of N_2 1P Δv=3 and partial with Δv=2 where dominated emissions with upper state vibrational number v=4, 5 and 6, i.e., N_2 1P (4, 2), (4, 1), (5, 2) and (6, 3). The imager recorded 630 nm-filtered emissions (I_{630}) were contributed primarily from N_2 1P (10, 7) with v=10 while N_2 1P (3, 1) for 762 nm-filtered emissions (I_{762}) with v=3. Hence, we calculated the emission ratios of I_{630} to I_{1P}, I_{630} to I_{762} and I_{762} to I_{1P}. The emission ratios of I_{630} to I_{1P}, I_{630} to I_{762} and I_{762} to I_{1P} also reflect the relative vibrational distributions of vibrational levels with LOW v=3 (I_{762}), MIDDLE v=4, 5, 6 ($I_{1P,}$ 623 – 754 nm), and HIGH v=10 (I_{630}). Therefore, we use the Boltzmann temperature for indicating the relative vibrational distributions of the specified group (LOW/MIDDLE/HIGH) of N_2 ($B^3\Pi_g$) vibrational levels. For ISUAL recorded sprites, the average brightness of N_2 1P (I_{1p}), 762 nm (I_{762}) and 630 nm (I_{630}) emission was 2.3, 0.6 and 0.02 MR. The N_2 ($B^3\Pi_g$) vibrational temperatures (T_v) were estimated to be 2800 K, 3200 K and 4300 K for multi-band emission ratios of I_{630}/ I_{1p}, I_{630}/ I_{762} and I_{762}/ I_{1p}. For observed elves, the average brightness I_{1p}, I_{762} and I_{630} were 170, 50 and 3 kR. The estimated T_v values were 3700 K, 3700 K and 3800 K for ratios I_{630}/ I_{1p}, I_{630}/ I_{762} and I_{762}/ I_{1p}. For observed gigantic jets, the derived T_v values were 3000 – 5000 K for a ratio I_{762}/ I_{1p}. Through N_2 ($B^3\Pi_g$) T_v analyses from emission ratios of ISUAL multi-band observation, we derived the N_2 ($B^3\Pi_g$) vibrational temperature that ranges between 3000 and 5000 K or higher in TLEs. Accuracy and variations of derived N_2 ($B^3\Pi_g$) T_v are also discussed while the relative population of vibrational levels in the Boltzmann equilibrium are also compared with past spectra observation. The details are shown in the publication (https://doi.org/10.1029/2019JA027311).

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